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SKY RADIOBACKGROUND AND RADIOLUMINOSITY FUNCTION

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SUMMARY

The expected brightness of the extragalactic component of the radiobackground is compared with that obtained from measurements made by various authors.

The results can be explained by an increase in concentration of galaxies, which are used to determine the radioluminosity function, and this, evidently, is connected with the existence of the Vaucouleurs Super-galaxy.

\* \* \*

The sky background intensity, conditioned by radioemission of remote galaxies, is determined by the radioluminosity function of galaxies and by the law (model) of Universe expansion. The luminosity function is usually written in the form

$$\lg \frac{\Delta \rho}{\Delta M_R} = a M_R + b = \lg \varphi,$$

where  $\Delta \rho / \Delta M_R$  is the spatial plane of galaxies referred to the unitary interval of absolute radiomagnitudes  $M_R$ ;  $a$  and  $b$  are certain constants. We shall express the radioluminosity of galaxies by the quantity  $P$  (w cps str) referred to the frequency of 160 Mc/sec. With the aid of the correlation

$$M_R = 34.0 - 2.5 \lg P$$

the luminosity function may be represented in the form

$$\frac{\Delta \rho}{\Delta P} P = 5.8 \cdot 10^{34.2+b} P^{-2.5a}.$$

Effecting the integration, we obtain the luminosity of volume unit conditioned by the galaxies, whose radioluminosity is included between the values  $P_1$  and  $P_2$ :

$$I = \int_{P_1}^{P_2} \frac{\Delta p}{\Delta P} P dP.$$

Such a method was applied for the determination of the luminosity unit of volume  $I_1$ , created by galaxies  $M_R < -20$  for the luminosity functions obtained by Roeder and Vittie [1] ( $a = 0.51$  and  $b = 7.8$ ), and by Pskovskiy [2] ( $a = 0.47$  and  $b = 7.1$ ). For the latter case the constants  $a$  and  $b$  were determined directly from the graph in the work [2], preliminarily "shifted" by the quantity  $\Delta M_R = 0.8$  in order to bring the absolute values to the frequency of 160 Mc/sec. The quantity  $I_1$  was found to be equal to 310 w/cps/sterad/ps<sup>3</sup> for the functions of [1] and 630 w/cps/ster/ps<sup>3</sup> for the functions of [2]. For the region  $-10 < M_R < -20$  we may obtain from the radioluminosity function the values  $a = 0.15$  and  $b = 0.65$ . The value  $I_2$  corresponding to them is equal to 160 v/cps/ster/ps<sup>3</sup>. For the parallel estimate of the value of  $I_2$ , we constructed the radioluminosity function of normal galaxies by the results of observations by Heeshen and Wade [3], who investigated the radioemission of all galaxies brighter than  $m_{pg} = 11.2$ , located to the North of the  $-19^\circ$  declination. The distances to the galaxies were determined by the red shift  $z$ , if the withdrawal velocity is not less than 1000 km/sec ( $cz \geq 1000$  km/sec), and by the module of the distance

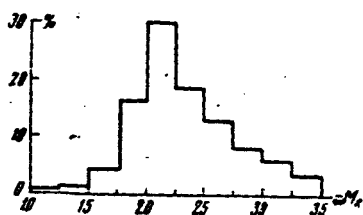


Fig. 1

$m_{pg} - M_{pg} - A$ , if the value of  $z$  is small or unknown. The absolute magnitudes of galaxies of various morphological types were borrowed from the Vaucouleurs work [4] and brought to the value of the Hubble parameter  $H = 100$  km/sec/M admitted in the present work. The obtained

radioluminosity function is characterized by the constants  $a = 0.35$ ,  $b = 3.8$ . The value of  $I_2$ , corresponding to the band  $-10 < M_R < -20$ , is then equal to 110 w/cps/ster/ps<sup>3</sup>.

Thus, if the observed spatial distribution of galaxies is not distorted by local fluctuations, each cubic parsec of space must emit, as an

average, 400 — 800 w/cps/ster. The histogram of Fig. 1 shows the fractions contributed to radiobackground by galaxies of different radioluminosity. As may be seen from the sketch, the main contribution to background is made by normal galaxies with  $M_R = -18 - 25$ .

Let us now pass to experimental verification. Costain [5] obtained the upper limit of the brightness temperature of the metagalactic component of radiobackground in the 3.7 m wavelength for the spectral index  $\alpha = 0.8$ , equal to  $240^\circ \text{K}$ . This corresponds to  $36^\circ \text{K}$  in the frequency of 160 Mc/sec.

In order to pass from temperature to spatial density of radioemission sources it is necessary to choose a specific model of the Universe. Let us utilize the general expression for the background brightness in a specific frequency  $\nu_0$ , obtained by Whitrow and Yallop [7] (equation (17)), which, in our denotations will take the form

$$B(\nu_0) = c \int_0^t I \left( \frac{\nu_0 R_0}{R(t)} \right) dt,$$

where  $I = I_1 + I_2$ ;  $R(t)$  is a function describing the expansion of the Universe. Estimating that  $R(t) \sim t^n$ ,  $I(\nu_0 R_0 / R) = I(\nu_0) (R_0 / R)^\alpha$ , we arrive at the following expression for the background intensity of radioemission:

$$B = c I(\nu_0) \cdot \int_0^t \left( \frac{R}{R_0} \right)^\alpha dt = \frac{c}{H} \cdot I(\nu_0) \frac{n}{\alpha n + 1}.$$

The background intensities, computed for various acceptable evolutionary models of the Universe, differ little from one another, which is explained by the fact that the contribution of galaxies to the general background diminishes as the distance to them increases, while the differences between models are perceptible only at very great distances. This is why we shall make use of the value  $B$ , corresponding to the Einstein-de Sitter model. Assuming  $n = 2/3$ ,  $\alpha = 0.8$ , we obtain  $B = 1300 \text{ Mps} \cdot \text{I}$ . On the other hand, the quantity  $B = (2kT/c^2)\nu^2$ . Hence  $I = 0.2 \cdot 10^{-47} \text{ erg/sec} \cdot \text{cm}^3 \cdot \text{cps} \cdot \text{ster} = 5.9 \text{ Tw/cps} \cdot \text{ps}^3 \cdot \text{ster}$ .

For the temperature interval  $26 - 46^\circ \text{K}$  we obtain  $I = 150 - 27 \text{ cps/ster/ps}^3$ . The comparison of this value with its value determined by the luminosity function, shows that the observed radioemission background is two to five times less than the expected one.

Let us recall that the main contribution to radiobackground is made by the frequently encountered galaxies of fairly low radioluminosity, whose radioemission may be observed only from small distances. Consequently, the mean densities of galaxies in the regions adjacent to our own Galaxy (within the radius of about 15 Mps, if one should judge by distances to identified sources of rather low radioluminosity) are two to five times higher than the density of galaxies in the Universe. This is evidently linked with the grouping of galaxies into clusters of second order — the supergalaxies. Thus, the function of radioluminosity of galaxies requires corrections for the existence of superclusters. Obviously, the correction will not affect the highluminosity part of the function, for the mean distance between powerful radiogalaxies exceeds significantly the dimensions of supergalaxies. Starting from that, it becomes possible to modify the Roeder and McVittie radioluminosity function in such a fashion that the galaxies with  $M_R < -20$  condition near 80% of the intensity of metagalactic radioemission, as this follows from Fig. 1. Such a function will have the form

$$\begin{aligned}\log \varphi &= 0.47 M_R + 6.5 \quad \text{at } H = 100 \text{ km/sec,} \\ \log \varphi &= 0.47 M_R + 6.4 \quad \text{at } H = 75 \text{ km/sec.}\end{aligned}$$

\*\*\* THE END \*\*\*

State Astronomical Institute  
in the name of Shternberg

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#### REFERENCES

- [1].- R. C. ROEDER, G. C. McVITTIE.- *Astrophys. J.*, 138, 889, 1963.
- [2].- Yu. P. PSKOVSKIY.- *Astronom. Zh.*, 41, 619, 1964.
- [3].- D. S. HEESHEN, C. M. WADE.- *Astronom. J.*, 69, 277, 1964.
- [4].- G. de VAUCOULEURS. *Problems of Extra-Galactic Research*, London 1961.
- [5].- C. H. COSTAIN, *Monthly Not. Roy. Astronom. Soc.*, 120, 248, 1960
- [6].- A. J. TURTLE, J. F. PUGH, S. JENDERLINE, I. I. K. PAULINY-TOTH.- *Ibid.* 124, 297, 1962.
- [7].- G. J. WHITROW, B. D. YALLOP, *Ibid.* 127, 301, 1964.

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